Chapter 5

Microwave Heating Assisted Biorefinery of Biomass

Sherif Farag
École Polytechnique de Montréal, Canada

Jamal Chaouki
École Polytechnique de Montréal, Canada

ABSTRACT

This chapter debates the potential of the biorefinery of biomass using microwave heating. First, the essential information regarding electromagnetic radiation is explained and the pros and cons of microwave heating versus conventional heating, especially in the thermochemical treatment of biomass, are discussed. Different methodologies for predicting and measuring the temperature gradient within a material subjected to electromagnetic waves are demonstrated. The chapter summarizes the key conclusions of various investigations regarding the effects of microwave heating on chemical reactions and presents how electromagnetic radiation can assist the biorefinery of biomass. Finally, the issues and limitations regarding scaling-up microwave heating are elucidated, along with possible solutions to these problems.

DOI: 10.4018/978-1-4666-8711-0.ch005

Copyright ©2015, IGI Global. Copying or distributing in print or electronic forms without written permission of IGI Global is prohibited.
INTRODUCTION

Fundamentals of Electromagnetic Waves

Electromagnetic radiation behaves like waves moving at the speed of light and photons carrying radiated energy. Electromagnetic waves are comprised of both alternating electric and magnetic fields that are orthogonal to each other and propagate in the direction of oscillation, as shown in Figure 1.

The history of electromagnetism dates back to 1831, when Michael Faraday discovered electromagnetic induction. Then, James Clerk Maxwell commenced working on Faraday’s concept, and in 1864 presented a mathematical framing to explain the combined impact of electric and magnetic fields that later became known as the electromagnetic theory. In Maxwell’s original paper, entitled “A Dynamical Theory of The Electromagnetic Field,” published in 1865, electromagnetic theory was presented through 20 equations. Thereafter, these equations were simplified into the forms known today as “Maxwell’s four equations”. The differential and integral forms of these equations are expressed in Equations (1) to (4). Equation (1) is Gauss’s law for an electric field, Equation (2) is Gauss’s law for a magnetic field, Equation (3) is Faraday’s law of induction, and Equation (4) is Ampere’s law (Gupta & Eugene, 2007):

Differential form:
Integral form: \( \nabla \cdot D = \rho \)

\[ \oint DdA = \int \rho dv \]  
(1)

Differential form:
Integral form: \( \nabla \cdot B = 0 \)

\[ \oint BdA = 0 \]  
(2)

Differential form:
Integral form: \( \nabla \times E = -\partial B/\partial t \)

\[ \oint E \cdot dl = -\int (\partial B / \partial t) \cdot ndA \]  
(3)

Differential form:
Sustainability, Business Models, and Techno-Economic Analysis of Biomass Pyrolysis Technologies
Innovative Solutions in Fluid-Particle Systems and Renewable Energy Management (pp. 298-342).
www.igi-global.com/chapter/sustainability-business-models-and-techno-economic-analysis-of-biomass-pyrolysis-technologies/132889?camid=4v1a